

# Gold Price Prediction using Machine Learning

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## ABSTRACT

Historically, among other payment forms, gold has been used to fund trading purchases around the globe. Several states have retained and increasing their gold deposits, and have been known as democratic and prosperous nations. Actually, precious metals such as gold are kept by central banks in all countries to guarantee external debt servicing, and even to manage inflation. Furthermore it also reflects the country's financial strength. In addition to government departments, numerous international companies and individuals have participated in gold reserves. In addition to the commodity's demand and supply on the market, the performance of the world's leading economies also greatly influences gold rates. This rise in gold value coupled with volatility and falling prices from other markets such as capital markets and real estate markets has attracted more and more investors to gold as an attractive investment. Although there is still strong uncertainty of the late gold market, and transactions in gold are getting more dangerous. There's a fear that those high prices will be sustainable and that the prices will reverse. Although there are a number of studies that analyze the correlation between the gold price and certain economic variables. Machine learning was often applied to predicting financial variables, but usually focused on predicting stocks rather than commodities. In this study, we proposed the development of forecasting model for predicting future gold price using Linear Regression (LR).

**KEYWORDS:** Gold ETF, Price prediction, Machine Learning, Supervised Learning, Linear Regression, Python

## 1. INTRODUCTION

### 1.1. Gold ETF

After launch of Mutual Funds, Exchange Traded Funds (ETFs) became the most revolutionary and common securities among investors in India. ETF instruments have created a valuable space among investors who find the trade-trick of analyzing and selecting stocks from their portfolio difficult to master. Most specifically, thanks to ETF's low cost and track record of performance, they have captured the investors' attention in a major way.

Investing in gold has developed over a period of time in conventional forms by purchasing jewelry or through modern methods, either by purchasing gold coins and bars (which are already accessible in scheduled banks) or by investing in Gold Exchange traded fund (Gold ETF).

A Gold ETF is an exchange-traded fund (ETF) to monitor the house price of the actual gold. These are defensive investing vehicles focused on gold, so they invest in gold bullion. In general, Gold ETFs are units of actual gold and can be in paper or dematerialized shape. Each unit of Gold ETF is equivalent to 1 gram of gold, which is supported by actual gold of extremely high purity. Gold ETFs integrate simplicity with equity ownership with the facility to trade in cash.

Gold ETFs are listed and exchanged on the National Stock Exchange of India (NSE) and Bombay Stock Exchange Ltd. (BSE) as securities of every business. As every other corporate stock, Gold ETFs transact on the cash segment of

BSE & NSE and can be regularly acquired and sold at market rates. Buying Gold ETFs implies buying gold in an electronic form. You can buy and sell gold ETFs just like you would trade stocks. When you actually reclaim Gold ETF you don't get actual gold but receive the cash equivalent. Gold ETF investing is done by a dematerialized portfolio (Demat) and dealer, rendering it an incredibly easy way to trade directly in the gold.

### 1.1.1. Gold ETF Benefits

- Potentially cheaper investment choice than other types of investing in gold.
- Quick and convenient deal via Demat Account.
- No Storage Cost & Investor Safety Issues.
- Transparent value for money.
- Taxation efficient-Mutual Fund Tax, No Wealth-Levy.
- Listed as a stock, and traded.
- Flexibility to purchase in small lots (minimum 1 unit=1 gram gold \*).

\* In some Gold ETFs one unit is the equivalent of half a gram of gold.

### 1.2. Price Forecasting

Price forecasting is calculating the price of a commodity / product / service by examining different factors such as the existence, pricing, seasonal trends, the costs of other products ( i.e. fuel), several manufacturer offers etc. Price forecasting can be a characteristic in consumer-facing travel

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applications used to improve customer loyalty and engagement, such as Train line or Hopper. Around the same period, certain businesses can still use details about potential costs. Entrepreneurs the need to determine an optimum period to buy a commodity to change the costs of goods or services that need a commodity (lumber, chocolate, gold), or to evaluate the investment value of fixed assets.

Price forecasting can be conceived as a regression function. Regression analysis is a statistical approach used to estimate the relationship between a variable dependent / objective (electricity price, flight time, property efficiency, etc.) and single or multiple independent (interdependent) or predictors affecting the target variable. Regression analysis often helps researchers assess how much impact such predictors have on a goal variable. Integer is also a guide word, for regression.

Price forecasting is usually performed using concise and predictive analytics.

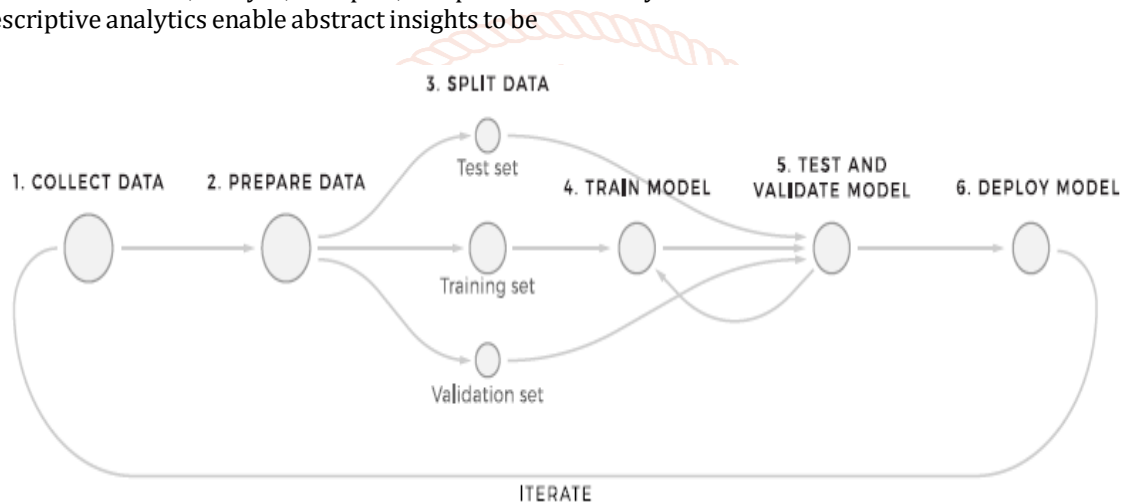
**Descriptive Analytics:** Descriptive analytics rely on statistical methods to collect, analyze, interpret, and present findings. Descriptive analytics enable abstract insights to be

converted into information that one can understand and communicate with others. In brief, this form of analytics can address the question what happened?

**Predictive analytics:** Predictive analytics includes evaluating real and past data in order to estimate the probability of future occurrences, outcomes, or prices in the form of market forecasts. Predictive modeling involves various computational methods, such as data mining (text pattern identification), and machine learning.

### 1.3. Machine Learning

Machine learning is a data analytics tool which automates the building of analytical models. It is a branch of artificial intelligence focused on the premise that systems with minimal human input can learn from data, recognize trends and make decisions. Machine learning is aimed at developing systems capable of identifying trends in the data, learning from it without human involvement and clear reprogramming. To solve the question of price prediction, data scientists will first understand what data to use to train machine learning models, and this is precisely why concise analytics are needed.

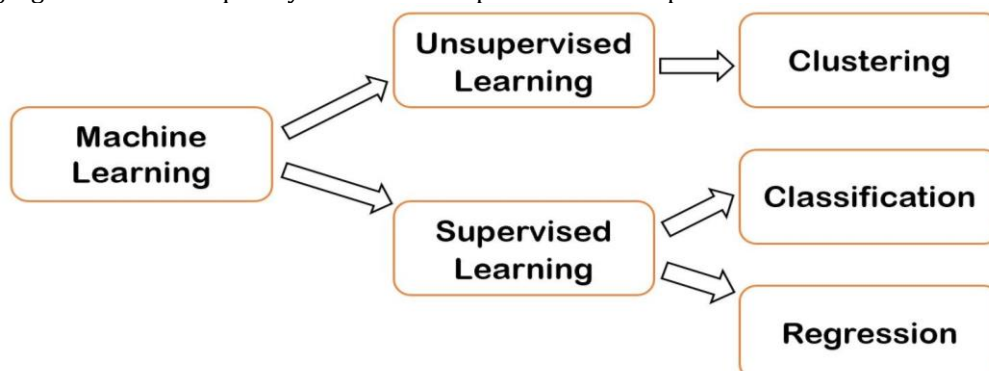


**Figure 1. Methodology used for price prediction using machine learning.**

The specialists then collect, pick, plan, pre-process and convert this data. Upon completion of this stage, the specialists begin building predictive models. A model that predicts prices at the maximum precision rate would be chosen to drive a device or program. And the price prediction function system might look like this:

- Statement on problem.
- Knowing the peculiarities of economies. Answering the question: What variables are affecting commodity / product / service prices?
- Gathering, preparing, and preprocessing data.
- Testing and modelling.
- Deploying a model into a software or application

Machine learning algorithms are frequently classified as supervised or unsupervised.



**Figure 2. Machine Learning Methods.**

### 1.4. Linear regression (LR)

Linear Regression is an algorithm of machine learning, based on supervised learning. It does the role of regression. Regression is a process using independent predictors to model a target value. This approach is often used to forecast and figure out the relationship between variables between cause and effect. Regression methods vary mainly in terms of the number of independent variables and the form of relationship between the independent and dependent variables.

Regression analysis is a reliable method for determining which variables affect a topic of interest. The regression process allows you to determine confidently which factors matter most, which factors can be ignored, and how those factors influence each other.

To completely understand regression analysis, comprehension of the following words is essential:

- Dependent Variable: The main factor we're trying to understand or predict is this.
- Independent Variables: These are the factors you hypothesize affect your variable dependent on.

To perform a regression study, we would need to identify a dependent variable that is determined by one or more independent variables that you hypothesize. Otherwise we would require a robust dataset to deal with. Managing surveys of interest to your audiences is a terrific way to set up this dataset. Survey will include questions that answer all of the objective variables we are involved in.

## 2. LITERATURE REVIEW

The buyers have been paying considerable attention in recent years to investments in the gold sector because of potential returns in the future. Gold is the only asset that retains its worth even through the political and economic downturn. The gold values are often directly linked to other resources. Future gold price forecast is the investors' alert mechanism because of unpredictable market risk. Therefore, precise forecasting of gold prices is needed to predict the market patterns. Several computational intelligent techniques for gold forecasting applications have been noted over the past decade, and the review of different models applied for these applications is as detailed below:

### 2.1. Previous work

[1] Xiaohui Yang, "The Prediction of Gold Price Using ARIMA Model", 2nd International Conference on Social Science, Public Health and Education 2019.

Although, 2016 and 2017 have risen, the global gold cost has been in the doldrums since 2013. The unpredictability of gold costs will profoundly affect the venture choices of people, endeavours and nations. This investigation centers around the figure of gold costs from July 2013 to June 2018 as indicated by the World Gold Council, and means to gauge and examine day by day gold cost of USD in the principal half of the period of July 2018 through the foundation of ARIMA model. This examination likewise utilizes AC, PAC, AIC, BIC to evaluate the precision of models. Exact results exhibit that ARIMA (3, 1, and 2) is the best model to anticipate the gold cost of USD. The gauge results of ARIMA Model are fundamental for individuals to comprehend the proficiency of gold costs and settle on incredible venture decisions.

[2] Manjula K. A., Karthikeyan P, "Gold Price Prediction using Ensemble based Machine Learning Techniques", Third International Conference on Trends in Electronics and Informatics, 2019.

This article depends on an investigation led to comprehend the connection between gold cost and those factors affecting it, to be specific financial exchange, unrefined petroleum value, rupee dollar conversion scale, swelling and loan cost. Month to month value information for the period January 2000 to December 2018 was utilized for the examination. The information was additionally part into two periods, period I from January 2000 to October 2011 during which the gold value displays a raising pattern and period II from November 2011 to December 2018 where the gold cost is indicating a flat pattern. Three AI calculations, direct relapse, arbitrary woodland relapse and inclination boosting relapse were utilized in examining these information. It is discovered that the connection between's the factors is solid during the period I and frail during period II. While these models show solid match with information during period I, the wellness isn't acceptable during the period II. While irregular backwoods relapse is found to have better forecast precision for the whole time frame, angle boosting relapse is found to give better exactness for the two time frames taken independently.

[3] Mrs. B. Kishori 1, V. Preethi, "Gold Price forecasting using ARIMA Model", International Journal of Research, 2018.

Gold is metal which is significant as fiscal resource, adornments, Investment choice. As venture choice it snatches the fascination of financial specialists by its high heightening costs. In any case, the gold cost isn't steady It varies consistently because of different reasons. This paper is intended to figure the gold value utilizing ARIMA model. For gauging it utilizes memorable information.

[4] R. Hafezi\*, A. N. Akhavan, "Forecasting Gold Price Changes: Application of an Equipped Artificial Neural Network", AUT Journal of Modeling and Simulation, 2018.

The figure of vacillations of costs is the significant worry in money related markets. Therefore, building up a precise and vigorous determining choice model is basic for financial specialists. As gold has demonstrated an exceptional capacity to smooth swelling variances, lead representatives utilize gold as a cost controlling switch. Hence, more data about future gold value patterns will help settle on the firm choices. This paper endeavours to propose a shrewd model established by counterfeit neural systems (ANNs) to extend future costs of gold. The proposed clever system is furnished with a meta-heuristic calculation called BAT calculation to make ANN fit for following variances. The structured model is contrasted with that of a distributed logical paper and other serious models, for example, Autoregressive Integrated Moving Average (ARIMA), ANN, Adaptive Neuro-Fuzzy Inference System (ANFIS), Multilayer Perceptron (MLP) Neural Network, Radial Basis Function (RBF) Neural Network and Generalized Regression Neural Networks (GRNN). So as to assess model execution, Root Mean Squared Error (RMSE) was utilized as a blunder list. Results show that the proposed BAT-Neural Network (BNN) beats both customary and current estimating models.



[5] Shian-Chang Huang and Cheng-Feng Wu, **Energy Commodity Price Forecasting with Deep Multiple Kernel Learning**, MDPI Journal, 2018.

Oil is a significant vitality ware. The challenges of determining oil costs come from the nonlinearity and non-stationarity of their elements. Nonetheless, the oil costs are firmly associated with worldwide money related markets and monetary conditions, which furnishes us with adequate data to anticipate them. Conventional models are direct and parametric, and are not extremely viable in foreseeing oil costs. To address these issues, this examination built up another procedure. Profound (or various levelled) different bit learning (DMKL) was utilized to foresee the oil value time arrangement. Customary strategies from insights and AI normally include shallow models; in any case, they can't completely speak to mind boggling, compositional, and various levelled information highlights. This clarifies why customary strategies neglect to follow oil value elements. This examination intended to take care of this issue by consolidating profound learning and various portion machines utilizing data from oil, gold, and money markets. DMKL is acceptable at abusing various data sources. It can successfully distinguish the significant data and all the while select a contrary information portrayal. The pieces of DMKL were implanted in a coordinated non-cyclic diagram (DAG), which is a profound model and proficient at speaking to intricate and compositional information highlights. This gave a strong establishment to extricating the key highlights of oil value elements. By utilizing genuine information for observational testing, our new framework vigorously beat customary models and fundamentally diminished the estimating mistakes.

### 3. PROBLEM FORMULATION AND RESEARCH OBJECTIVES

#### 3.1. Problem Formulation

From the above comprehensive literature review on different prediction methods in business applications utilizing analytical intelligent techniques throughout the past decades, it has been noted that the following problems are found when carrying out prediction processes for the business applications considered – foreign exchange rate prediction, stock market price prediction, gold price prediction:

- Unattained Scalability
- Premature Network Convergence model
- Trapping ourselves in local and global optima
- Stilling
- Large prognostic bias
- Overlapping computing energy
- The computational load of the algorithms increased
- No assurance on system's interpretability

#### 3.2. Research Objectives

This research work has proposed predictive models that are adaptive, flexible and scalable, using the advantages of proposed computationally smart neural network models to enhance the training learning process and enhance faster

convergence. The proposed research provides the highest likelihood of achieving high training rate prediction precision for the considered gold price forecast in the-market scenario, with marginal mean square error. Generally speaking, this work is performed to suggest suitable predictor models to effectively forecast the deemed gold in the business scenario with the datasets deemed from their respective databases on previous years.

This present's aim is to forecast correctly the future modified closing price of Gold ETF in the future for a specified period of time. In this study, supervised Machine Learning Algorithms and the solution model ensemble were used to determine whether or not to buy Gold ETF using a dataset of past values.

The main objectives of the present study are:

- This research is based on the applicability of the proposed machine learning algorithms that had demonstrated their efficiency to predict gold prices with a better predictive rate.
- To study different variables on which gold cost will depends and different Machine Learning Algorithm, Techniques might be utilized for value expectation.
- To apply a best appropriate Machine Learning procedures.
- In this study, we proposed the development of forecasting model for predicting future gold price using Linear Regression (LR).
- To break down and check the acquired outcomes

## 4. METHODOLOGY

### 4.1. Python

Python is a language of programming that is interpreted, of high level, of general use. The philosophy of Python's design, established by Guido van Rossum and first published in 1991, emphasizes code reading by promoting the use of large white space. The software structures and object-oriented methodology was designed to help developer, with large and small ventures, to build clear and logical code. Python is dynamically typed and garbage is collected. It embraces several programming paradigms, including organized (particularly procedural), object-oriented, and functional programming. Python is also defined as a "battery included" language due to its extensive standard library.

The Python 2 version was officially retired in 2020 (previously foreseen for 2015), and "Python 2.7.18 is the new iteration of Python 2.7 and, therefore, the final Python 2 update." Only Python 3.5.x is supported, and later, with the end of life of Python 2.

### 4.2. Dataset

Data for this study are collected from source (<http://www.etf.com/GLD>) from January 2005 through August 2020. GLD is the largest ETF with direct investments in actual gold.



**Figure 3. Shows Gold ETF rate from January 2005 through August 2020.**

With golden bars stowed in London vaults, GLD tracks gold spot rates, reduce costs and responsibility. GLD is the first to explicitly markets actual gold assets. The product structure reduced investors' problems in the purchase, storage and insurance of physical gold bullion. The NAV is measured with the LBMA PM Gold Price (formerly the London PM Gold Fix), which is the explanation why the GLD is extremely similar in its association with spot prices. The arrangement safeguards creditors as trust grantors; trustees cannot lend the gold bar. Nevertheless, long-term taxation on income can be high, as the IRS finds the GLD a collectible. GLD's NAV also has a bigger handle which corresponds to a higher gold exposure per share.

#### 4.3. Proposed methodology

Supervised Learning is one of the progressing redesigns of guileless Regression. Regression handles the issue of self-governance by averaging all models created by regular one dependence estimator and is suitable for continuous learning. Regression creates great results stood out from ordinary models.

- Probabilistic request learning framework.
- Preferable for educational records where there is dependence among characteristics.
- Predicts class probabilities.
- Useful for tremendous enlightening assortment.

The arranged procedure of my thesis task is Supervised Learning such as Regression. Supervised Learning strategy is the directed learning procedure which is used for expectation of gold cost. Optimization practiced for upgrade the value an incentive from chronicled period. This strategy expands the precision of PR bend. In this way, we are explaining the arranged gold forecast with normal for various components which impacts to gold costs. The imminent of the Supervised Learning is outlined on a 3D object gratefulness work through the gold value database and different elements whose impact on cost of gold.

Changed Supervised Learning computation is a multilayer perceptron that is the one of a kind arrangement for conspicuous confirmation of two-dimensional substance information. Consistently have more layers: input layer, convolution layer, test layer and yield layer. In addition, in significant framework building the convolution layer and test layer can have different. Supervised Learning isn't as kept Boltzmann machine, ought to be the point at which the layer of neurons in the bordering layer for all affiliations, Supervised Learning counts, each neuron don't need to do feel overall substance, just feel the area the substance. Likewise, every neuron boundary is set to the equal, to be explicit, the sharing of burdens, specifically every neuron with a comparable convolution pieces to de-convolution content. The regression method follow in this way

- Setup of environment: load and read libraries
- Data analysis: consider the value of the factors and the statistical strength
- Engineering Feature: Direct data retrieval capabilities
- Preprocessing: parking data, handling missing values, categorical encoding variables, scale
- Selection of functions: just hold the most important variables
- Design model: baseline, train, validation, testing.
- Evaluation of performance: read measurements
- Explain skills: consider how the model forecasts

**Step-1: Import all the necessary** libraries which are required to implement this strategy. Then we read and store Gold ETF values in Df over the last fifteen years. We delete not applicable columns and drop NaN values with dropna (). We then draw the close price of Gold ETF.

#### Step-2. Define explanatory variables

An explanatory variable is a controlled vector that will decide the importance of the next day's Gold ETF level. These are essentially the tools we want to use to forecast the price of the Gold ETF. For this approach, the causal variables are the shifting

five-day and ten-day average. The NaN values are reduced using the dropna () function and stored in X. However, we could add more variables to the X which you think are useful for predicting the price of Gold ETF. The prices of other ETFs, such as Gold Mining ETF (GDX) or Oil ETF (USO) or U.S. economic information, could be the technical indicators.

### Step -3 Define dependent variable

The variable based on the explanatory factors always relies on the values. Simply put, that's the price of the Gold ETF that is familiar to us. The Gold ETF price is stored in y.

### Step-4 Split the data into train and test dataset

In this stage, the predictors and output data are divided into train and test data. The training data was used by comparing the input with the predicted outcome for constructing the linear regression model. The test data was used to approximate the training of the software.

1. For training and remaining testing details, first 75% of the data are used.
2. X train & y train are databases of testing
3. Checks are X test & y test

### Step-5 Creating a linear regression model

A linear regression model will be developed. What is a linear regression, however? If we attempt to obtain a statistical connection between 'x' and 'y,' which describes 'y' by comparing a line across a scatter plot to the observed 'x' values, so the relationship between x and y is called a linear regression study. To dismantle things more, regression describes the shift of an independent variable. The variable you want to predict is the dependent variable-' y'. The identical factors - 'x' are the explanations used to estimate the dependent variable. The following regression equation describes that relation:

$$y=(m_1 \times X_1)+(m_2 \times X_2)+C$$

$$\text{GoldETFPrice}=(m_1 \times 5 \text{ daymovingaverage})+(m_2 \times 10 \text{ daymovingaverage})+C$$

**They still use this fit approach for the development of coefficients and constants for regression, to match the independent and dependent (x and y) variables.**

### Step 6. Predicting the Gold ETF prices

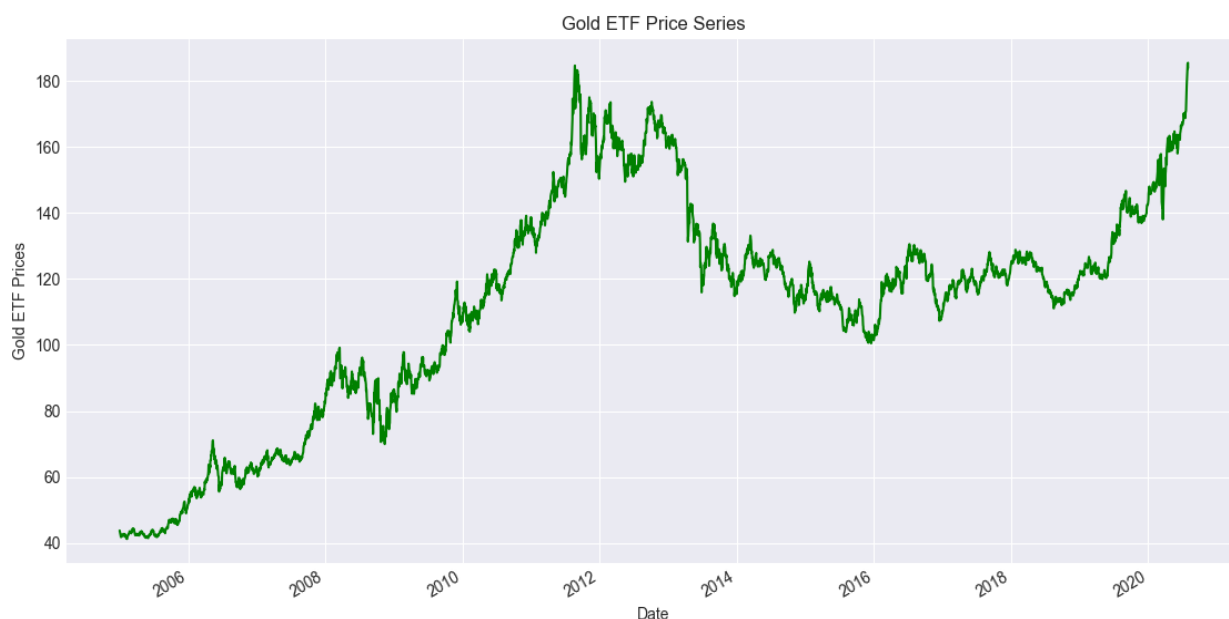
It is now time to check how the concept fits in the research dataset. In the linear model created by the dataset, we are predicting the price of Gold ETF. For the given explanatory variable X, the predict method determines the price of Gold ETF(y).

### Step-7 Plotting cumulative returns

To evaluate its results, let us measure the accumulated returns for this technique. The following steps are taken to calculate the total returns:

- Generate regular change in gold price percentage
- Build a trading symbol "1," whether the expected price of the next day is greater than the forecast price of the present day. There is no other place held
- Compute the returns for strategy by using the trading signal to multiply the change of daily percentages.
- We can eventually construct the accumulated graph of returns

## 5. RESULTS AND DISCUSSIONS



**Figure 4. Gold ETF price from January 2005 to August 2020**

**Output of Regression Model:**

Gold ETF Price (y) =  $1.4523852334619429260698098 * 5 \text{ Days Moving Average (x1)} + -0.4546956945100898428435698 * 10 \text{ Days Moving Average (x2)} + 0.3003405311223872331538587 \text{ (constant)}$



**Figure 5: The graph above shows the expected and actual Gold ETF price.**

The assurance coefficient, or R squared, is a factual proportion of how close the information sets are to their coordinated relapse line inside a range. This measure ranges from 0 to 1, demonstrating the degree of consistency of the needy variable inside an informational collection. The R square of 0 methods the autonomous variable can't anticipate the reliant variable, while a R square of 1 methods it very well may be anticipated without mistake.

**# Coefficient of determination or R squared**

```
rsquare_score = linear.score(X [t:], y [t:])*100
float("{0:.2f}".format(rsquare_score))
```

**Output: 98.76%**

As we can see, the model's R-square is 98.76 percent. R-squared is usually 0 to 100 per cent. A score close to 100 per cent indicates that the Gold ETF prices are well explained by the given model.



**Figure 6. Cumulative return**

The Sharpe proportion which Nobel laureate William F. Sharpe presented in 1966 is a measure for figuring hazard balanced return. The Sharpe proportion is the normal return per unit of vulnerability increased over hazard free expense.



We additionally ascertain the Sharpe proportion utilizing:

'Sharpe Ratio  $\% .25f$ ' % (gold['strategy\_returns'].mean()/gold['strategy\_returns'].std() (252\*\*0.5))

### Output: 'Sharpe Ratio 0.89945'

We may now use the following application to forecast the gold prices and send a trading signal as to whether we can purchase GLD or not.

```
data = yf.download('GLD', '2005-01-01', '2020-08-01', auto_adjust=True)
```

```
data['S_5'] = data['Close'].rolling(window=5).mean()
```

```
data['S_10'] = data['Close'].rolling(window=10).mean()
```

```
data = data.dropna()
```

```
data['predicted_gold_price'] = linear.predict(data[['S_5', 'S_10']])
```

```
data['signal'] = np.where(data.predicted_gold_price.shift(1) < data.predicted_gold_price, "Buy", "No Position")
```

```
data.tail(3)
```

### Output:

Date	Open	High	Low	Signal	s_5	s_10	Predicted Gold Price
29-07-2020	184.009995	186.14	182.39	Buy	183.703	177.409	181.456
30-07-2020	183.440002	184.33	182.13	Buy	184.213	178.924	181.931
31-07-2020	184.509995	185.75	184.17	Buy	184.773	180.534	181.693

## 6. CONCLUSIONS

Gold has been one of history's most significant commodities. Maintaining central banks' gold reserves is essential to maintaining the world's existing economic system. Some big firms and investors are now spending large amounts of money in gold. While forecasting the rate of gold is not very easy, it will allow investors and central banks to determine better when to sell and buy them and thus maximize their income. Furthermore, an attempt has been made in this study by using machine learning algorithms to accurately predict the gold prices and when to sell them and purchase them. This research was done in order to clarify the gold ETF price predictions using machine learning using Python. The research was carried out for data between January 2005 and August 2020.

The results on proposed model is as per the following:

- It is concluded that machine learning algorithms with linear regression analysis are very useful in gold price prediction.
- It is concluded that, the model's R-square is 98.76 percent. R-squared is usually 0 to 100 per cent. A score close to 100 per cent indicates that the Gold ETF prices are well explained by the given model.
- It is concluded that, the model's Sharpe proportion is 0.84495 The Sharpe proportion which is a measure for figuring hazard balanced return. The Sharpe proportion is the normal return per unit of vulnerability increased over hazard free expense.
- Results show that proposed linear regression method-machine learning beats customary and current predicting models.
- The new estimating model updated on the gold cost dataset, and the results showed that the forecast model is beating other benchmark models, such as ARIMA, ANN and ANFIS.

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